UNIVERSITY II SERIES

MODEL 435
LINEAR/LOG RATEMETER

INSTRUMENT
CENTER

OPERATING
AND
INSTRUCTION
MANUAL

BAIRD-ATOMIC
33 UNIVERSITY ROAD, CAMBRIDGE, MASSACHUSETTS 02138

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Model 435 Linear/Log Ratemeter

Operating and Instruction Manual

MODEL 435 LINEAR/LOG RATEMETER

Figure 1.1

CHAPTER
1

GENERAL DESCRIPTION

Linear/Log Ratemeter Definition

The Model 435 Linear/Log Ratemeter is a fully transistorized laboratory instrument designed to convert radioactive count rates to an analog output. The Model 435 has both a current and voltage input: the current input accepts count rates directly from a photomultiplier or gas counter; the voltage input accepts count rates from a preamplifier.

The Model 435 amplifies, discriminates, and converts the incoming count rate from digital to analog information. The count rate may be recorded on standard strip chart recorders by using the outputs on the rear panel. Simultaneously, the count rate is monitored on a linear or logarithmic front panel meter, and may also be monitored on an internal howler.

GENERAL DESCRIPTION

The Model 435 supplies a metered high voltage for gas counters and photomultipliers and low voltage for Baird Atomic transistorized preamplifiers. The Model 435 Linear/Log Ratemeter, coupled with a detector and recorder, provide an efficient and economical system for radioactive count rate data gathering.

Linear/Log Ratemeter Specifications

The published linear/log ratemeter specifications are fully as important as the instrument described, for the data provides a description necessary to correctly use the Model 435. Since Baird Atomic products benefit from a program of continuing evaluation and improvement, specifications are subject to modification.

General

Input	Negative input; current gain 50; direct photomultiplier and gas counter input; 20 ua full scale input. Voltage gain 10; preamplifier input 1 volt nominal full scale input
Pulse Height Selector	0.25 volt to 10 volts sensitivity; 0 to 100% pulse height selection
Resolution	Better than 1 us resolution (i.e., the Model 435 can resolve pulse pairs closer than one microsecond at the highest or lowest count rate)
Output	3-1/2 x 3" meter $\pm$2% linearity

Output (Cont.)	0 - 1 ma recorder 0 - 10 mv recorder } linearity 1% 0 - 100 mv recorder 2" speaker audio output
Recorder Full Scale Adjust	100% scale expander on all recorder outputs
Recorder Scale Factor	A switch is available on the lower front panel to double the mv recorder output
Linear Output Response Ranges	Thirteen ranges: 0-100, 200, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K, 1M counts per minute
Time Constant	Eight time constants: 0.1, 0.5, 1.0, 5.0, 10.0, 50.0, 100.0, 300.0 seconds
Calibration	The calibration position is available on the time constant switch to check the output level against the 3600 cpm line frequency
Background Suppress	0% to 100% of the background count rate may be subtracted with the BACKGROUND SUPPRESS control
Zero Adjust	The linear range ZERO ADJUST control is a front panel screwdriver adjustment to zero the output voltage with no input
Logarithmic Output	
Range	10^1 to 10^6 5-cycle log scale
Linearity	$\pm$2% of full scale (read on linear scale)
Time Constant	Composite

GENERAL DESCRIPTION

High Voltage	0 to 3000 volts; 0 - 500 ua continuously variable
Preamplifier Connector	7-pin Amphenol signal input and ground $\pm$18 volts available at 10 ma
Dimensions	8-1/2" wide x 7" high x 15" deep
Weight	Approximately 10 pounds

CHAPTER
2

OPERATION

Preliminary Check and Installation

No special precautions are required other than those normally taken with commercial type laboratory equipment. However, the following steps are suggested for the operator's convenience.

1. With the line cord unplugged and no detector connected, check to see that the needle on the meter face is at zero. If adjustment is required, use the screwdriver adjustment on the front of the meter face to reset to zero.
2. Set the TIME CONSTANT switch on CAL, the RANGE switch on 5K, the BACKGROUND SUPPRESS on 0 per cent, the PULSE HEIGHT SELECTOR switch on 20 per cent, the SCALE

FACTOR switch on X1 and the LIN-HV-LOG switch on LIN.

3. Plug the line cord into the 110 volt AC receptacle (if a three-wire plug is not available, an adaptor may be used and the ground wire run to the nearest conduit).
4. Set the OFF-STANDBY-ON switch to STANDBY and adjust the AUDIO control on rear panel to the desired level. The tone produced should be approximately 60 cps.
5. Note that the count rate indication on the 5K range of the meter is approximately 3600 cpm.
6. Set the TIME CONSTANT switch to 0.1 second and recheck for electrical zero.
7. Set the LIN-HV-LOG switch to HV. Turn the OFF-STANDBY-ON switch ON; vary the HV control from full counter-clockwise to clockwise. The meter should read over 3KV. After checking the HV range, turn the control fully counter-clockwise. Set the OFF-STANDBY-ON switch to the OFF position.

If the linear/log ratemeter is used on a bench, nothing that would tend to block air circulation should be placed on top. Four rubber feet are provided to allow air to enter the ventilated bottom of the cabinet and exit through the top. When used in rack mounting applications, take care not to exceed the maximum operating temperature specified.

Controls, Indicators and Connectors

All frequently used linear/log ratemeter controls and indicators

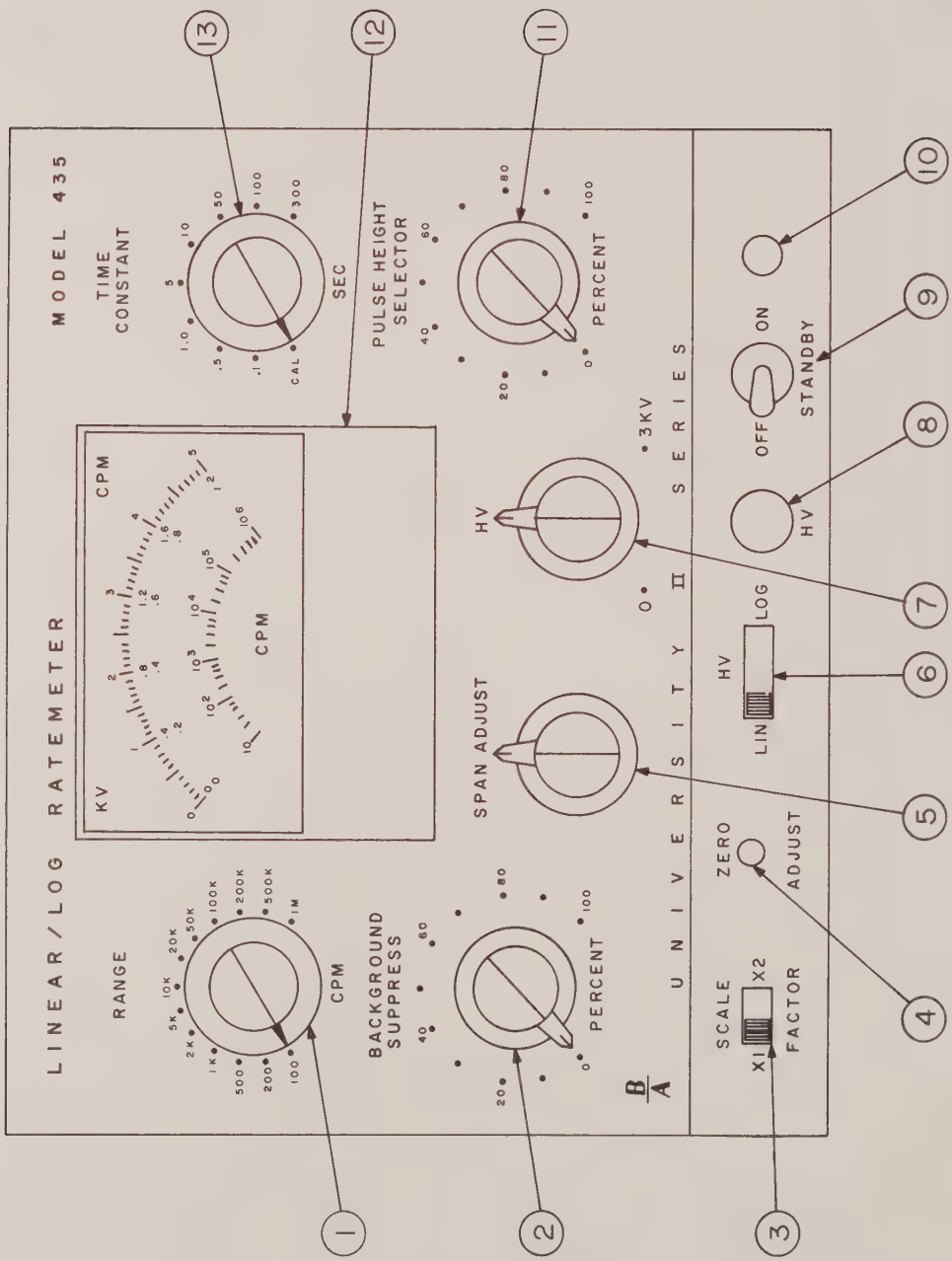
are conveniently located on the front panel; controls used less frequently and connectors are mounted on the rear panel. Front panel controls and indicators, as illustrated in Figure 2.1, are functionally separated: mode switches are mounted on the lower switch panel, and controls with an indicator on the main front panel. Chart 1 relates these controls and indicators to Figure 2.1 while describing each control and indicator by function.

Certain controls, fuses, and all connectors are mounted on the rear panel. Figure 2.2 illustrates these items; Chart 2 complements the figure.

FRONT PANEL CONTROLS AND INDICATORS

Chart 1

REF. NO.	NOMENCLATURE	FUNCTION
(1)	RANGE	Selects one of 13 possible ranges for ratemeter output
(2)	BACKGROUND SUPPRESS	Provides up to 100 per cent full scale background suppression for the linear output amplifier
(3)	SCALE FACTOR	Doubles the 10 mv or 100 mv recorder output if a greater recorder swing is required at lower output levels



FRONT PANEL CONTROLS AND INDICATORS

Figure 2.1

FRONT PANEL CONTROLS AND INDICATORS

Chart 1 (Cont.)

REF. NO.	NOMENCLATURE	FUNCTION
(4)	ZERO ADJUST	Zeros the linear output amplifier driver with screwdriver adjustment
(5)	SPAN ADJUST	Adjusts output of the linear recorder to a full scale recorder output
(6)	LIN-HV-LOG	Switches the meter reading from linear to high voltage or logarithmic display; also switches the audio circuit from linear to log response
(7)	HV (0 - 3KV)	Adjusts the high voltage from 0 to 3000 volts
(8)	HV	A high voltage indicator which lights when the high voltage is on

FRONT PANEL CONTROLS AND INDICATORS

Chart 1 (Cont.)

REF. NO.	NOMENCLATURE	FUNCTION
(9)	OFF-STANDBY-ON	In OFF all power is turned off; in STANDBY all power is turned on except the high voltage (which is in standby); in ON the high voltage as well as the low voltage is turned on
(10)	Pilot Lamp	Indicates that power is being applied when lighted
(11)	PULSE HEIGHT SELECTOR	Selects the pulses from the input amplifier according to height, from 0 to 10 volts
(12)	Meter	Indicates five scales: three scales indicate the linear ranges in multiples of 1, 2, and 5; the high voltage scale is indicated in red; the log scale is the bottom scale on the meter

FRONT PANEL CONTROLS AND INDICATORS

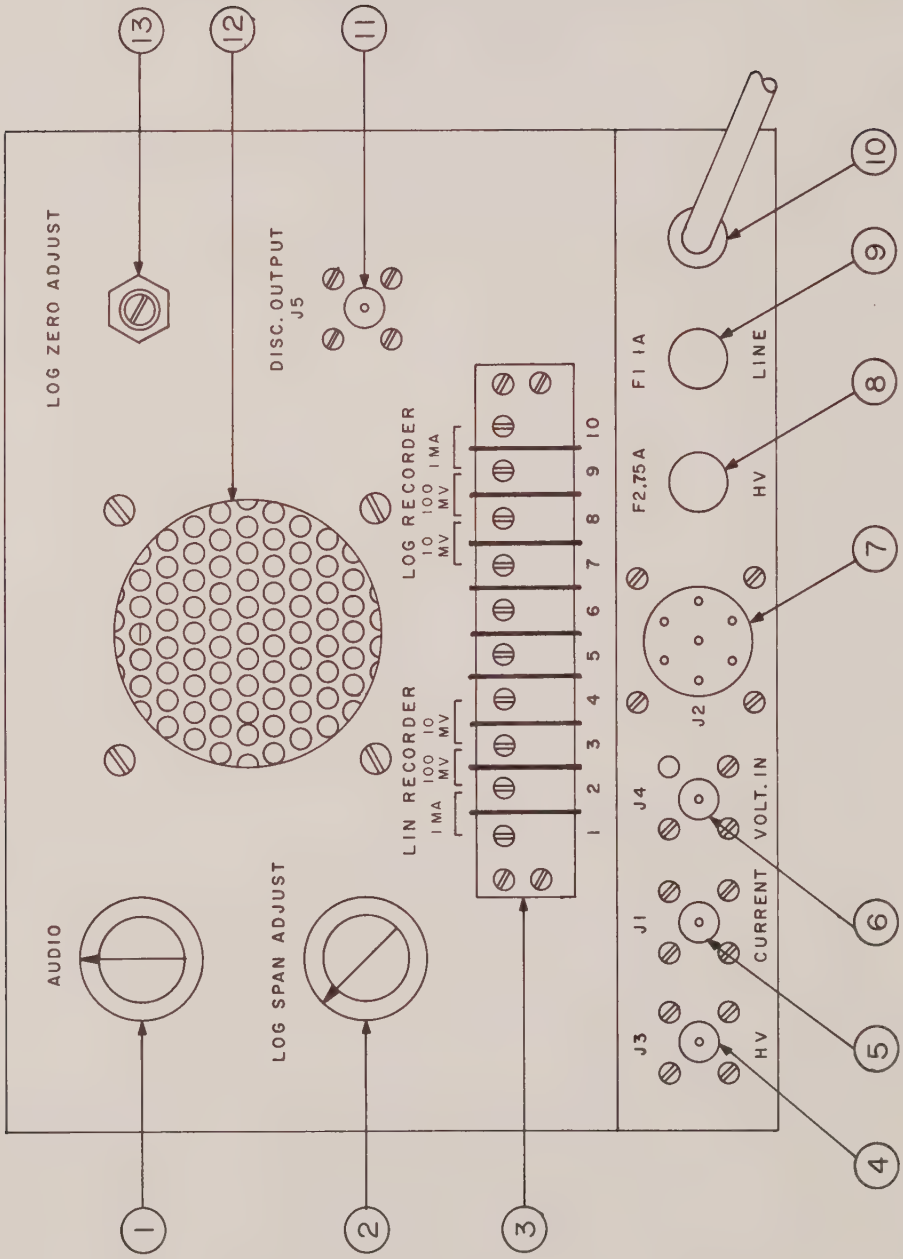
Chart 1 (Cont.)

REF. NO.	NOMENCLATURE	FUNCTION
(13)	TIME CONSTANT	Selects one of eight possible time constants to smooth the ratemeter output; the CAL position feeds 3600 cpm to the ratemeter for linear or logarithmic ranges

REAR PANEL CONTROLS, FUSES AND CONNECTORS

Chart 2

REF. NO.	NOMENCLATURE	FUNCTION
(1)	AUDIO	Controls the audio indicator; audio may be turned completely off when not in use
(2)	LOG SPAN ADJUST	Adjusts the logarithmic recorder output for full scale



REAR PANEL CONTROLS, FUSES AND CONNECTORS

Figure 2.2

REAR PANEL CONTROLS, FUSES AND CONNECTORS

Chart 2 (Cont.)

REF. NO.	NOMENCLATURE	FUNCTION
(3)	LIN RECORDER-LOG RECORDER	The terminal strip is marked for both logarithmic and linear 1 ma, 100 mv and 10 mv recorder outputs; both linear and log recorders may be used simultaneously
(4)	J3 HV	High voltage is available from this output BNC
(5)	J1 CURRENT	Current input is brought in through this BNC NOTE: A resistor is connected between the current input and high voltage line so only one input cable is required from a detector for both high voltage as well as signal.
(6)	J4 VOLT. IN	Voltage input to the amplifier

REAR PANEL CONTROLS, FUSES AND CONNECTORS
Chart 2 (Cont.)

REF. NO.	NOMENCLATURE	FUNCTION
(7)	J2 (preamp)	The 7-pin connector provides ±18 volts for a preamplifier
(8)	F2.5A HV	Fuses high voltage
(9)	F1 1A LINE	Fuses AC input line
10	Line Cord	Connects to power outlet; normally 115 volts AC, 60 cps, the third wire tied to equipment ground
(11)	DISC. OUTPUT J5	Provides a standardized pulse which may be used to drive a scaler
(12)	Speaker	Provides audio tone to indicate decrease or increase in count rate; maximum audio tone pitch approximately 1000 cps

REAR PANEL CONTROLS, FUSES AND CONNECTORS
Chart 2 (Cont.)

REF. NO.	NOMENCLATURE	FUNCTION
(13)	LOG ZERO ADJUST	Adjusts the offset for the logarithmic amplifier

Recorder

The linear/log ratemeter may be operated with a 100 mv, a 10 mv, or a 1 ma recorder for either a logarithmic or linear output. (Such recorders are available and described in the Atomic-Accessories or Baird Atomic catalogs.)

1. Connect record to appropriate terminals on the rear panel barrier strip.
2. Plug in the recorder and turn on the chart drive motor.
3. Turn on the linear/log ratemeter and set the TIME CONSTANT switch to the CAL position. The recorder should indicate the proper count rate. If the pen goes in the wrong direction, reverse the leads on the recorder.

NOTE

Always jumper pins 1 to 2 and 9 to 10 on barrier strip for recorders other than 1 ma type.

OPERATION

Detector Plateau Curve

One of the characteristics exhibited by Geiger Mueller gas flow and scintillation detectors is the dependence of count rate on the value of high voltage applied to them. From a graph plotted of high voltage vs. count rate, this area of proper operating voltage can be determined.

The curve is obtained by plotting the count rate from a radioactive sample against the tube voltage for several different voltages without changing the physical conditions of relationship during the measurement. The point at which the detector first starts to indicate counts is the starting potential. The curve will start to climb, and then level off to a plateau where the count rate is relatively independent of the high voltage setting. The proper point of operation is one-third the length of the plateau above the threshold (= point where the plateau starts).

Obtaining the Plateau Curve

1. Connect the GM tube scintillation detector or gas counter to J1 CURRENT on the rear panel. If a Baird Atomic preamp is used, the cable should be connected to J2 preamp and the cable to J3 HV. If a preamplifier output is available separately it may be connected to J4 VOLT. IN and the high voltage cable to J3 HV.
2. Always set the HV control fully counterclockwise to insure no damage to the detector.
3. Place a radioactive source under the detector.
4. Set LIN-HV-LOG switch to LOG and set RANGE switch to the range indicated on the log scale of the meter.
5. If no recorder is used, increase the HV (clockwise) until a

count rate indication is shown on the meter, then back off 100 volts.

6. Using the HV control to increase the high voltage in 100 volt steps, note the count rate. Do not increase the high voltage beyond a reasonable range.
7. Set LIN-HV-LOG to LIN.
8. Set the TIME CONSTANT switch on a fairly fast time to obtain initial data.
9. If the count rate is too high for the range, increase the distance between sample and detector until a suitable count rate is obtained.

Proper Count Rate Range

Whenever possible, the meter indication of count rate should be in the upper two-thirds of the meter scale. This range will give the greatest meter accuracy of the count rate. The RANGE switch provides 13 graduations of count rate in counts per minute (cpm).

If the count ratemeter is to be used for localizing radioisotope concentrations and the audio indication of change in count rate is more important than the meter reading, the proper range will depend not only on the counting rate but also on individual preference. To obtain the proper range setting under these conditions, place the detector near a radioactive source of the same energy used during the measurement. Adjust the distance from the detector to the source until the count rate is approximately that which is expected to be encountered. Set the RANGE switch to 1M. Turn the RANGE switch down scale (counterclockwise) one step at a time until the tone increases

in pitch. This position is the highest range that will indicate a decrease in count rate.

Lower ranges should be tried until one is found where the pitch of the tone is comfortable to the listener. Do not use too low a range where the tone is near its maximum pitch of approximately 1000 cps, since the linear/log ratemeter will then not be able to indicate a further increase in count rate.

Time Constants

The TIME CONSTANT switch provides eight time constants. Increased statistical accuracy results when the TIME CONSTANT switch is set to a higher reading, but time is also sacrificed since it takes longer for the meter to reach equilibrium after a change in count rate.

The proper time constant depends on the accuracy desired and the relative time the count rate will remain constant. If accuracy is desired and sufficient time is available, use a long time constant. If the count rate is rapidly changing or insufficient time is available, then use a fast time constant.

The time constant at which the meter needle remains steady gives the maximum possible statistical accuracy for any one set of conditions. Any further increase will tend to subtract from the data being collected, for the meter will take longer than necessary to come to equilibrium if the count rate should suddenly change.

CHAPTER
3

LINEAR/LOG RATEMETER THEORY

General

All components necessary for fast qualitative analysis in either linear or logarithmic presentation are provided in the Model 435 Linear/Log Ratemeter. Figure 3.1, the overall linear/log ratemeter logic diagram, illustrates functional relationships.

Signal Flow

An incoming signal, amplified through a non-overloading feedback pulse amplifier, is applied directly from a photomultiplier tube or a gas counter through J1 CURRENT. When a pulse height analyzer or preamplifier is used the signal is applied through J4 VOLT. IN. Discriminator threshold is set by the PULSE HEIGHT SELECTOR control which standardizes the input pulse. A decade divider divides the major frequency

ranges by 2, 5, and 10. The pump circuit, which performs digital-to-analog conversion on the standardized pulses, is followed by an integrating amplifier to make the output voltage more linear. Output voltage determines the audio circuit frequency; the howler (or speaker) changes frequency, therefore, as the output voltage varies with the incoming count rate.

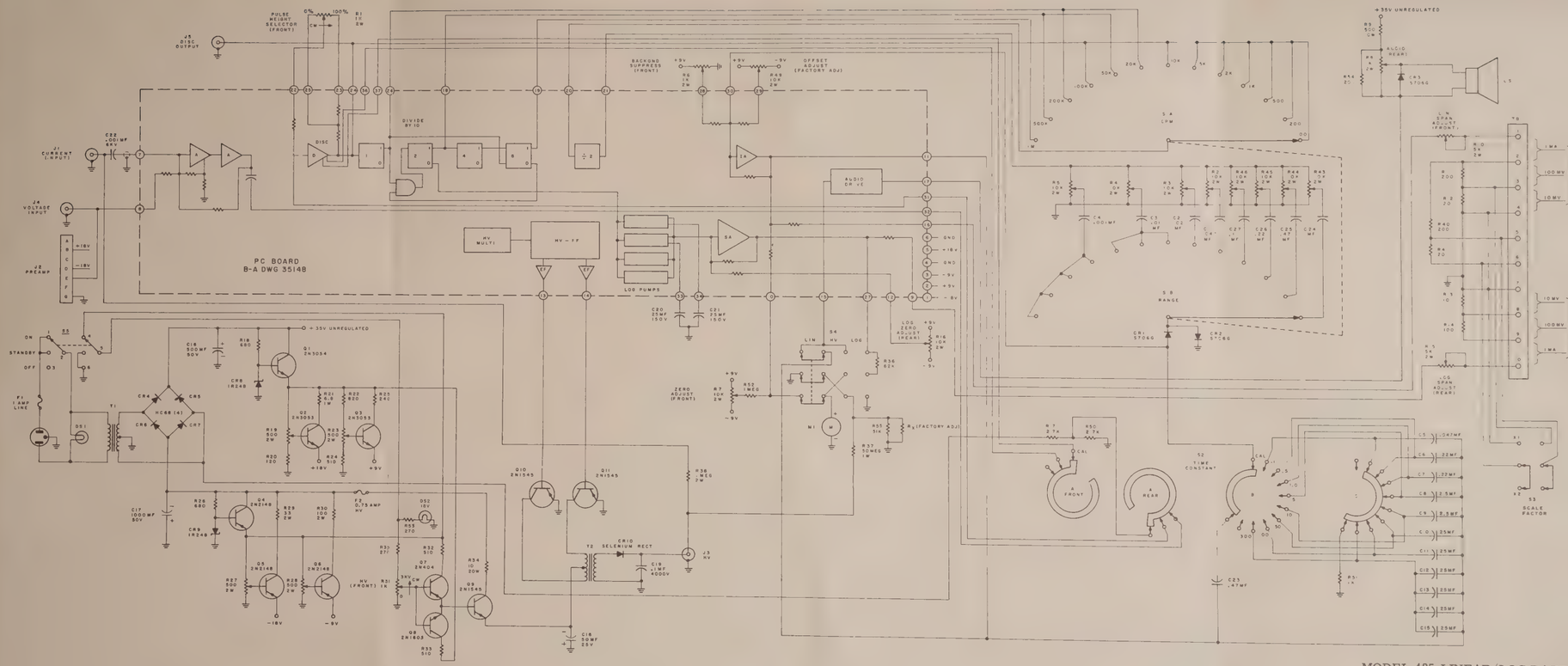
Input Amplifier

The input amplifier, a non-overloading pulse amplifier with both voltage and current input, consists of two stages. Stability and gain of each stage is controlled by a feedback loop. A major feedback loop is taken around the two stages of the amplifier to control stability and frequency response of the overall amplifier. The resolution of the amplifier is better than 1 us.

The first stage consists of two doublet stages connected in a stabilized current gain configuration. Each doublet is made up of a grounded emitter stage driving a grounded base stage in complementary cascade arrangement. This configuration has proven advantages: high speed operation is enhanced due to the low impedance base-to-emitter junction, shunting the high collector impedance, and effectively eliminating the Miller multiplication of base-to-collector capacity. As a further advantage, many such stages may be directly coupled with no "creeping up" of operating points normally encountered in other direct-coupled stages, for each stage can operate with zero volts in and zero volts out.

In the first stage negative feedback is employed around the two doublets to establish the stage gain. Frequency stabilization networks

RANGE	FREQ HZ.	PERIOD
100	1.66	600.2 ms
200	3.33	300.4 ms
500	8.33	120.0 ms
1K	16.6	60.2 ms
2K	33.3	30.0 ms
5K	83.3	
10K	166	
20K	333	
50K	833	
100K	1.66K	
200K	3.33K	
500K	8.33K	
1M	16.6K	



MODEL 435 LINEAR/LOG RATEMETER
LOGIC DIAGRAM
Figure 3.1

control the upper 3 db point of the stage which has a bandwidth of about 3 mc.

The first stage is a current amplifier with a fixed gain of 50; the second stage is a current-to-voltage converter. With 20 ua input, there is approximately 9 volts output. The voltage input has a gain of 10.

Pulse Height Selector

The pulse height selector is a differential discriminator. The PULSE HEIGHT SELECTOR setting establishes the reverse bias on the base-to-emitter junction of the input transistor. With no pulse present, the input transistor is turned off and the output transistor saturated. When an input pulse exceeds the reverse bias of the pulse height selector, the transistor states are reversed with the input transistor conducting. The output pulse is a standardized pulse height.

Divider

The divider circuit consists of four flip-flops labeled 8, 4, 2, 1, consistent with the binary-coded decimal. Up to the tenth pulse the counter functions like a normal binary counter. Each flip-flop divides the input frequency by two. When the eleventh sets FF1, FF2 remains reset because the gate inhibits this pulse. FF1 being set resets FF8 and the counter is reset to its initial condition.

The following truth table and divider block diagram illustrates the divider steps.

DECADE TRUTH TABLE

Chart 3

Flip-Flop 8	Flip-Flop 4	Flip-Flop 2	Flip-Flop 1	Pulses
0	0	0	0	1
0	0	0	1	2
0	0	1	0	3
0	0	1	1	4
0	1	0	0	5
0	1	0	1	6
0	1	1	0	7
0	1	1	1	8
1	0	0	0	9
1	0	0	1	10
0	0	0	0	

Linear Pump Circuits

Resistors R2 through R5, and R43 through R46 are used to adjust the amplitude of the input voltage swing. The standardized square wave is fed through C1 through C4, and C24 through C27 depending upon the range selected.

The pump circuit converts the repetition rate to a proportional DC voltage. Positive-going wave fronts are shunted through C2 to ground. The negative-going wave fronts are enabled through CR1 and charge the time

constant capacitors switched in around the integrating amplifier.

The charge into the pump circuit is q = cv; current into the input capacitor is i_{in} = frequency xq = fcv. When the input capacitor is fully charged and the system is stabilized i_{in} and i_{out} = fcv

$$e_o = i_{out} R = f(cvR).$$

Accordingly, the output voltage is proportional to the incoming frequency; the integrating amplifier then drives the strip chart recorders.

The background suppress drives a positive current into the base of the integrating amplifier. But the incoming current from the diode pump circuit has to overcome this current before an output is seen. The ZERO ADJUST on the integrating amplifier and summing amplifier provides negative or positive current into the base of the integrating amplifier and summing amplifier. This brings the output of these amplifiers to zero when no signal is applied.

Logarithmic Pump Circuit

The pump circuit is employed in the logarithmic as well as the linear output. Each pump, with differing time constants, has a logarithmic response. The sum of the individual pump circuits provides an output current logarithmically related to the incoming frequency. Pump outputs are summed in a summing amplifier which also drives the strip chart recorders.

Audio Output

The audio output may be fed from the linear or logarithmic output amplifier. The level of the voltage varies the frequency of the audio

multivibrator, giving an audio output proportional to the input frequency. The audio driver drives the speaker which may be turned off using the AUDIO control.

High Voltage Supply

The high voltage supply is a DC-to-DC converter. A 10 kc multivibrator is used to drive the high voltage flip-flop which in turn drives a step-up transformer. The center tap of the primary to the transformer is tied to a variable DC voltage. As the voltage on the center tap is increased, the voltage swing on the flip-flop driver is increased and the high voltage on the secondary of the transformer is also increased. High voltage is rectified and brought out to a high voltage connector. Low voltage on the primary center tap has been converted to a high voltage output.

Low Voltage Supply

The low voltage supply is a full-wave rectified, zener-regulated, emitter-follower supply. The zener establishes the level; potentiometers are used to adjust the proper level required by the board.

CHAPTER
4

MAINTENANCE

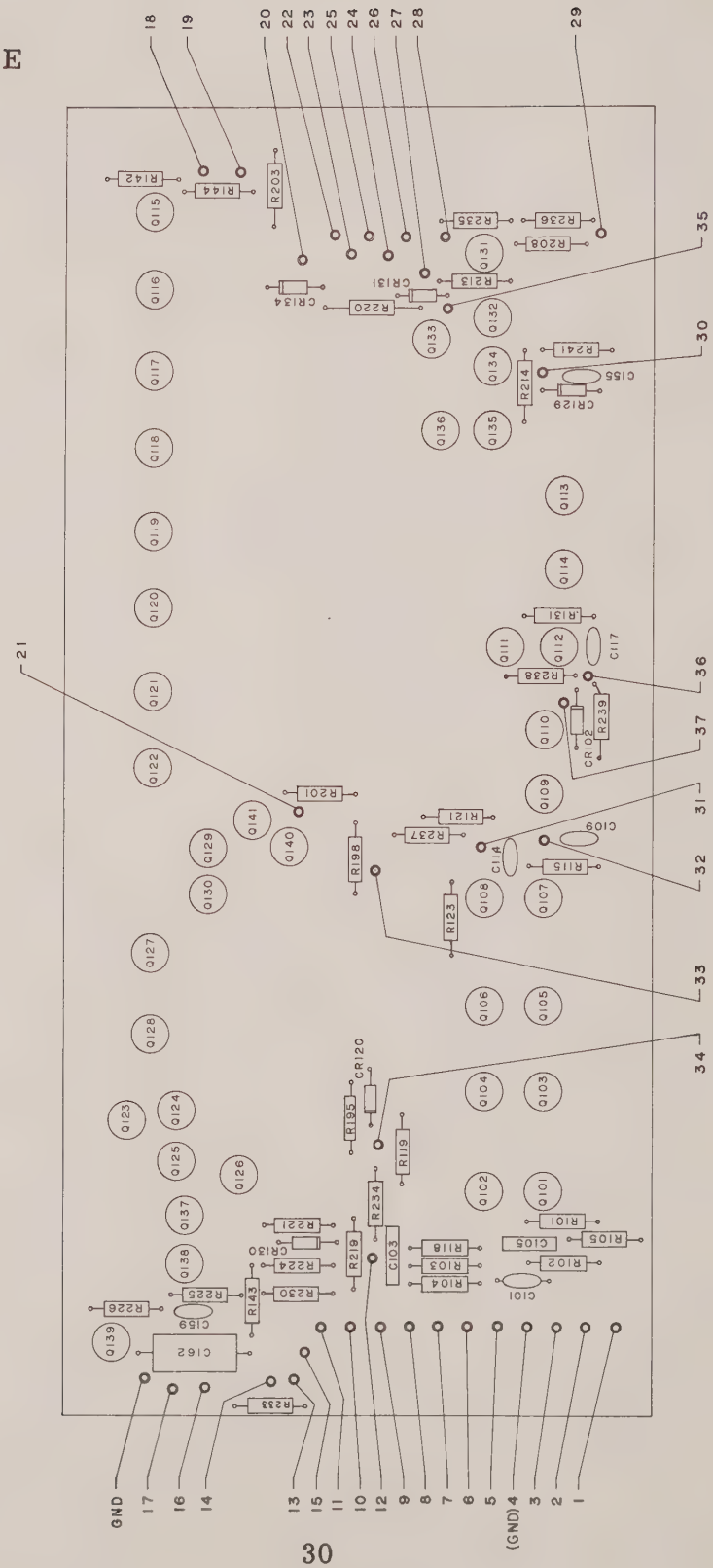
The design and fabrication of Model 435 Linear/Log Ratemeter lends itself to long-lasting operation without care other than that normally given electronic instruments. Problems that arise in the printed circuit board can easily be located by using the printed circuit board layout shown in Figure 4.1.

Troubleshooting

The linear/log ratemeter was designed for long, trouble-free operation. Worst case end-of-life parameters were considered in equipment design, derating where necessary to insure operation under wide environmental conditions. Troubleshooting is facilitated by an easily accessible printed circuit board. Should it be necessary to replace a switch assembly, it is essential that an identical switch be installed and the original lead dress copied exactly.

If problems appear in the linear/log ratemeter, refer to Chapters 2 and 3 for guidelines. Apply a command signal and trace it through using Figure 3.1 to isolate and clarify technical problems.

If a trouble cannot be easily located and corrected, contact the nearest Baird Atomic office.



PRINTED CIRCUIT BOARD LAYOUT

Figure 4.1

CHAPTER
5

PARTS LIST

All Model 435 Linear/Log Ratemeter components are fully identified in order to make possible procurement of replacements. Reference designations appear schematically on the linear/log ratemeter logic diagram Figure 3.1, and identify electrical/electronic component parts referenced in drawings or text; mechanical parts which are not likely to requirement replacement during normal linear/log ratemeter service life are not assigned reference designations or included in this parts list. For easy location all items given a reference designation in the parts list are arranged in alpha-numerical order. Exact linear/log ratemeter panel stamping, when it exists, is reproduced as part of the name of component and description column. Those few items listed without an assigned reference designation are included last in alphabetical order.

MODEL 435 LINEAR/LOG RATEMETER PARTS LIST

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
DS1	Power lamp, red neon, 110 volts	30497
DS2	HV lamp, red incandescent, 18 volts	32116
F1	Line fuse, 1 amp, 125 volts, SLO-BLO	00723
F2	HV fuse, .75 amp, 250 volts, SLO-BLO	00753
J1	J1 CURRENT, MHV connector	00698
J2	J2 PREAMP, 7-pin connector	00742
J3	J3 HV, MHV connector	00698
J4	J1 VOLT. IN, BNC connector	00756
J5	J5 DISC. OUTPUT, BNC connector	00756
LS1	Speaker	20584
M1	Meter	35218
R1	PULSE HEIGHT SELECTOR, potentiometer, 1 k, 2 watts	35271
R6	BACKGROUND SUPPRESS, potentiometer, 1 k, 2 watts	35271
R7	ZERO ADJUST, potentiometer, 10 k, 2 watts	35355
R8	AUDIO, potentiometer, 1 k, 2 watts	35271
R10	SPAN ADJUST, potentiometer, 5 k, 2 watts	35325
R15	LOG SPAN ADJUST, potentiometer, 5 k, 2 watts	35325
R16	LOG ZERO ADJUST, potentiometer, 10 k, 2 watts	35355

MODEL 435 LINEAR/LOG RATEMETER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
R31	HV, potentiometer, 1 k, 2 watts	35271
S1	RANGE, rotary switch, 2-pole, 2-17 position	35269
S2	TIME CONSTANT, rotary switch, 4-pole, 9-position	35268
S3	SCALE FACTOR, slide switch, DPDT	30472
S4	LIN-HV-LOG, slide switch, 3-pole, 3-position	35340
S5	OFF-STANDBY-ON, toggle switch, 2-pole, 3-position	30619
T1	Power transformer	01422
T2	HV transformer	35315
TB1	Barrier strip, 10-pin	35288
	Fuseholder	00646
	Instruction manual	35449
	Knob, skirted round	30393
	Knob, finger grip lock	31112
	Knob, finger grip lock pointer	31113
	Knob, round	31117
	Line cord, 3-wire	00979
	Printed circuit board assembly	35261
	Socket lamp	08971

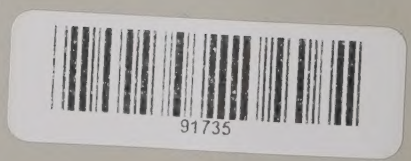
MODEL 435 LINEAR/LOG RATEMETER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
	Speed clip lamp	08972
	Strain relief	00279
	Terminal board	35314
	Terminal strip, 5-lug	00171

APPENDIX

MODEL 435 LINEAR/LOG RATEMETER SCHEMATIC DRAWINGS

DWG. NO.	NAME
D-35148	PC Board
D-35247	Lin/Log Ratemeter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